



DEPARTMENT OF ENERGY
OFFICE OF FOSSIL ENERGY

# CYCLIC CO<sub>2</sub> STIMULATION TO IMPROVE CO<sub>2</sub> FLOODING — OXY'S FIELD PROJECT

### **Project Description**

In this project, Oxy USA, Inc., is demonstrating the advantages of applying advanced reservoir management techniques, hydraulic fracturing and cyclic  $\mathrm{CO}_2$  stimulation to improve the economics and efficiencies of  $\mathrm{CO}_2$  floods in previously waterflooded carbonate reservoirs in the Permian Basin of West Texas. Working in the South Welch Unit, Oxy used advanced three-dimensional seismic imaging and log and core analysis to obtain a thorough description of the San Andres Formation reservoir to assist in the design of the most effective recovery processes. Fractures were created by injecting pressurized fluids into the reservoir strata to provide gas injection efficiency. The length and orientation of the fractures were determined to design the most efficient reservoir fluid flow patterns.

Cyclic (huff-n-puff)  ${\rm CO_2}$  stimulation was begun by injecting  ${\rm CO_2}$  into the well, then temporarily shutting in the well for up to four weeks. The  ${\rm CO_2}$  reacts with the oil, reducing its viscosity. The oil is then easier to move, and can be more efficiently "swept" to a producing well by water pumped into the reservoir from an adjacent injection well. Computer simulation and monitoring the fluid flow reactions help to optimize the location of other injection wells to be used in the field-wide flood. These stimulation treatments are intended to increase oil production more quickly, generating revenue to help pay back the large front-end investment.

As of December 1995, five wells have undergone cyclic  $\mathrm{CO}_2$  stimulation treatment: one well has shown results that would enhance economics of a  $\mathrm{CO}_2$  flood; one well has shown increased production; two wells showed increased oil rates, but did not make up for the lost production from the shut in and soak period; and one well showed no response. Oxy is currently refining its understanding of the reservoir by incorporating rock and fluid analysis with the 3-D seismic interpretations, and will use this improved geologic description to evaluate the results of the well treatments.

# **Program Goal**

The Department of Energy's Oil Program incorporated DOE and industry input to determine technologies that could effectively overcome barriers to production and prolong the productive life of the nation's domestic oil fields. Cyclic  $CO_2$  injection is one of those that industry recommended for the carbonate reservoirs of the Permian Basin.

Successful demonstration that the  $\mathrm{CO}_2$  huff-n-puff process can be operated economically in the Permian Basin and in other areas where larger, more expensive types of  $\mathrm{CO}_2$  flooding would not be used will provide operators with the incentive to implement the process. An estimated 2 billion barrels could be recovered from the Permian Basin San Andres reservoirs, and as much as 5.5 billion barrels throughout the U.S., using this technology.

# PRIMARY PROJECT PARTNER Oxy USA, Inc Midland, TX

FOSSIL ENERGY
PROGRAM
Oil Passyons Field

Oil Recovery Field Demonstration

MAIN SITE
Welch Field
Dawson Co., TX

TOTAL ESTIMATED
COST
\$22.2 million

COST SHARING

DOE - \$11.1 million

Non-DOE - \$11.1 million

DE-FC22-93BC14990

#### **Project Partners**

**Oxy USA, Inc.** Midland, TX

**HALLIBURTON SERVICES** Midland, TX

**T. SCOTT HICKMAN & ASSOCIATES** Midland, TX

RESERVOIR SIMULATION RESOURCE CORP. Tulsa, OK

**ADVANCED RESERVOIR TECHNOLOGIES** Dallas, TX

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#### **Project Benefits**

The Permian Basin of West Texas and Southeast New Mexico represents approximately one-third of the U.S. oil reserve potential from shallow shelf carbonate reservoirs. Many of the fields have been producing from these reservoirs for over 40 years, and the remaining oil is becoming more difficult to produce with current technologies.

 ${\rm CO_2}$  flooding has the technological capability to recover remaining reserves, but the high cost of obtaining  ${\rm CO_2}$  supplies and installing  ${\rm CO_2}$  flood facilities prevents operators from applying the technology in lower-quality carbonate reservoirs. The projects cannot be justified economically, given the relatively long time between installation of  ${\rm CO_2}$  flood facilities and significant increases in production.

Oxy's demonstration of applying advanced reservoir imaging and analysis, rock fracturing and cyclic  $CO_2$  stimulation combined with computer simulation and monitoring techniques is designed to show that this multidisciplinary approach can improve the economics and efficiency of  $CO_2$  flood projects in the Welch Field. The field was discovered in 1936; waterflooding began in 1958 and was expanded to full field in 1972. The Welch Field has produced over 63 million barrels of oil from the San Andres Formation, 21.5% of the original oil in place. Oxy's goal is to recover an additional 1.7 million barrels of oil from the South Welch Unit, and demonstrate that using these technologies can make  $CO_2$  flooding economically attractive at the West Welch Unit, where the process was previously considered infeasible.

Successful demonstration of these technologies will have a rapid impact in both the Permian Basin, because of the abundance of  $\mathrm{CO}_2$  sources and services, and in other carbonate reservoirs where capital-intensive  $\mathrm{CO}_2$  flood projects would otherwise not be used. Additional reserves producible by cyclic  $\mathrm{CO}_2$  stimulation in the Permian Basin San Andres reservoirs are estimated at 2 billion barrels of oil—5.7 million barrels in the West Welch Unit alone, and the total U.S. domestic production potential could be as much as 5.5 billion barrels.

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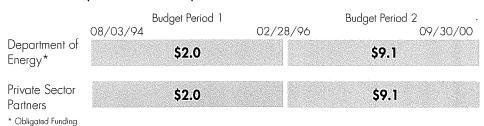
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## Cost Profile (Dollars in Millions)



#### **Key Milestones**

